
CLAIMS

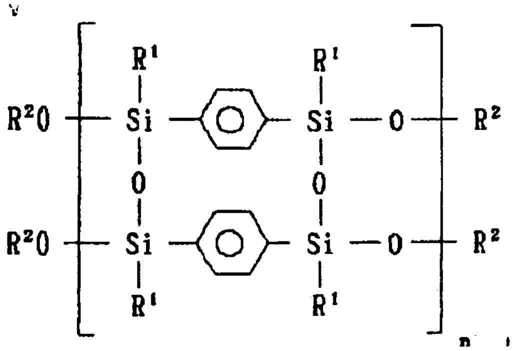
[Claim(s)]
[Claim 1] The manufacture approach of the semiconductor device characterized by to include the process which is the approach of manufacturing the semiconductor device which has the multilayer-interconnection structure which consists of two or more wiring layers and an interlayer insulation film arranged among them, forms the resin layer for flattening with an organic silicon polymer on a lower layer wiring layer, forms the inorganic material film and forms an interlayer insulation film subsequently to this resin layer top by the vacuum deposition by ion beam assistance, or the ion plating by high-frequency excitation.
[Claim 2] The approach according to claim 1 characterized by performing vacuum deposition by said ion beam assistance, neutralizing the charge of a vapor-deposited substrate front face.
[Claim 3] The approach according to claim 1 characterized by performing ion plating by said high-frequency excitation, performing ion beam assistance.
[Claim 4] The approach of any one publication to claims 1-3 characterized by said organic silicon polymer which forms the resin layer for flattening being sill phenylene resin.
[Claim 5] The approach of any one publication to claims 1-4 characterized by said inorganic material film being film of diacid-ized silicon.

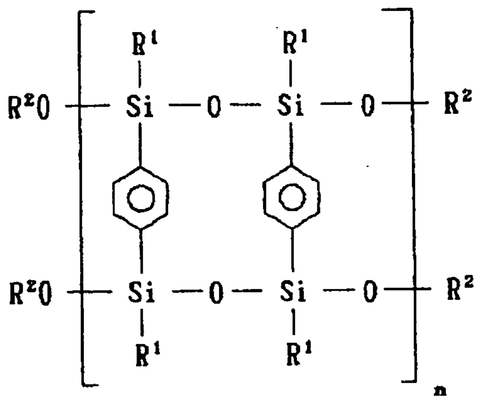
[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the manufacture approach of a semiconductor device. If it says in more detail, this invention relates to the manufacture approach of a semiconductor device of having the multilayer-interconnection structure which consists of two or more wiring layers and an interlayer insulation film arranged among them.
[0002]
[Description of the Prior Art] In a semiconductor device with high degrees of integration, such as IC in recent years and LSI, while the surface level difference after component formation becomes large with improvement in a degree of integration, in order to prevent the fall of the wiring capacity by detailed-izing of wiring, there is an inclination for the level difference after wiring to also become intense, as a result approached by the need of thickening wiring. For this reason, formation of the interlayer insulation film with which the outstanding surface smoothness is obtained when giving the N+1st-layer wiring through an insulator layer and forming a multilayer interconnection after giving the Nth-layer wiring is needed.
[0003] Conventionally, as an ingredient of an interlayer insulation film, the layered product of organic system macromolecule insulating materials, such as inorganic materials, such as a silicon dioxide, silicon nitride, and PSG, or polyimide, and silicone resin, or these inorganic materials and organic system polymeric materials has been used.
[0004] since the semi-conductor substrate front face which wired between components has a level difference with the irregularity by wiring at the multilayer-interconnection process in manufacture of a semiconductor device -- this -- a substrate -- carrying out -- a it top -- chemical vapor deposition (CVD) -- if the inorganic film is formed as an interlayer insulation film by law etc., the front face of this interlayer insulation film will reproduce the irregularity of a substrate as it is. This irregularity becomes the open circuit of the upper wiring and poor insulation's cause which are formed on it. Therefore, the interlayer insulation film formed on the substrate of having irregularity was wanted to be able to make a substrate front face evenly. Then, the approach of acquiring a flat side from on insulator layer manufacture processes, such as the etchback method and the bias spatter method, and the method of forming resin with a spin coat method and obtaining a flat insulator layer have been examined.
[0005] After applying resin, it is necessary to carry out heat hardening of the easy resin applying method in process in these approaches. Moreover, since the silicone system rebound ace court ingredient used from the former turns into an ingredient of the low-fever expansion coefficient near silicon oxide after hardening and it is easy to generate a crack by the membranous internal distortion and the membranous thermal shock by the hardening reaction, the film which could use it only with the thin film but was formed with this ingredient for that reason has the problem that electric insulation is low. On the other hand, an organic radical oxidizes at the temperature of about 400 degrees C, or the pyrolysis of polyimide resin, the silicone resin, etc. is carried out, and they have the fault that a crack occurs by distortion of the film.
[0006] Thus, it is difficult to use organic system polymeric materials independently as an interlayer insulation film ingredient of the multilayer interconnection of the semiconductor device with which the degree of integration progressed. then, the resin film top as a flattening layer -- further -- SiO2 etc. -- the approach of forming the inorganic material film and using as an interlayer insulation film is examined, and in order to be formation of this inorganic material film, the vacuum deposition method and the plasma-CVD method are used.

[0007]
[Problem(s) to be Solved by the Invention] Since it is generally easy to produce a pinhole on the formed film in a vacuum deposition method, it is SiO2. In order to use an inorganic substance high-melting [like] as the film with sufficient electric insulation, the substrate to which the resin film was attached must be made into an elevated temperature, and thickness must be set to 1 micrometers or more. Therefore, in the vacuum deposition method, membranous production took time amount, the heat-conduction property of an integrated circuit was reduced, and problems, such as causing property degradation, have arisen.
[0008] On the other hand, it compares with a vacuum deposition method by the plasma-CVD method, and is precise SiO2. Since the film is obtained, it is SiO2. By thousands of A, although thickness is good Since adhesion with the resin film which is not so precise as the inorganic film in a crack arising in a flattening layer as a result of the resin film which is a substrate oxidizing by the plasma impressed at the time of film formation is low, There was a problem of the inorganic film separating from the resin film with a next up layer formation process on the occasion of processings, such as required heating at high temperature and etching.
[0009] This invention is SiO2 on the substrate resin film, without making the substrate resin film for flattening produce a crack etc., while flattening of the level difference which solves many of these problems and is produced at the multilayer-interconnection process of a semiconductor device is possible. The manufacture approach of the semiconductor device which can be made to be fully able to stick the inorganic material film [like], can form, and can produce an interlayer insulation film is offered, and it aims at enabling manufacture of a reliable semiconductor device.
[0010]
[Means for Solving the Problem] The manufacture approach of the semiconductor device of this invention is the manufacture approach of a semiconductor device of having the multilayer-interconnection structure which consists of two or more wiring layers and an interlayer insulation film arranged among them, and is characterized by to include the process which forms the resin layer for flattening with an organic silicon polymer on a lower layer wiring layer, forms the inorganic material film and forms an interlayer insulation film subsequently to this resin layer top by the vacuum deposition by ion beam assistance, or the ion plating by high-frequency excitation.
[0011] In case the inorganic material film is formed with the vacuum deposition by ion beam assistance in the approach of this invention, a new trad riser may neutralize the charge of a vapor-deposited substrate front face. Moreover, in case the inorganic material film is formed by the ion plating by high-frequency excitation, ion beam assistance may be performed.
[0012] It is desirable that it is what has the property fused at low temperature in the case of heat curing so that flattening of the surface level difference of a substrate wiring layer can be carried out good, and the crack by the thermal shock cannot generate easily while the organic silicon polymer used in order to form the lower layer for flattening has thermal resistance. The typical thing of such an organic silicon polymer is sill phenylene resin (poly sill phenylene siloxane). A silicon atom is the high polymer of the network structure combined through the phenylene group through the oxygen atom, and sill phenylene resin is expressed with the following general formula.
[0013]
[Formula 1]





[0014] It sets at this ceremony and is R1. It may be mutually the same as that of others, and may be different from each other, a low-grade alkyl group or a phenyl group is expressed, respectively, and it is R2. The Tori organosilyl group is expressed. Moreover, n expresses the number of values with which the weight average molecular weight of this organic silicon polymer is set to 5,000-5,000,000. If the polymer of this molecular weight out of range is used, it will become difficult to form the flattening resin layer of an interlayer insulation film with sufficient convenience. The weight average molecular weight of a polymer is 10,000-500,000 preferably.
[0015] The sill phenylene resin expressed with the above-mentioned general formula is R1. It can hydrolyze, subsequently dehydration condensation can be carried out, and the disilyl benzene which has two silyl radicals which the low-grade alkyl group or phenyl group expressed, and the radical in which hydrolysis like an alkoxy group is possible have combined with the silicon atom can be prepared easily.
[0016] The inorganic material film which constitutes the upper layer of an interlayer insulation film is film of diacidized silicon (SiO2) preferably.
[0017]
[Function] Since the organic silicon polymer used by the approach of this invention has the property fused at low temperature, in case it is heat curing, it is fluidized easily, and it carries out flattening of the surface level difference of the wiring layer of a substrate good. And it is hard to generate the crack by the thermal shock, and this resin also enables use with a thick film.
[0018] Furthermore, an organic silicon polymer like sill phenylene resin being excellent in oxidation resistance, therefore using such an organic silicon polymer enables use of the etching system of the barrel type usually used at the resist exfoliation process.
[0019] while the vacuum deposition by ion beam assistance makes inert gas, such as an argon, an ion beam in the vacuum of 10-4 - 10-5Torr and a substrate is irradiated -- SiO2 etc. -- the membrane formation matter is vapor-deposited. Fundamentally, it is the kinetic energy which an ion beam has SiO2 It uses for an array in case membrane formation matter, such as a molecule, accumulates on a substrate, therefore therefore internal stress is small, it is precise and formation of the high film of array nature is enabled. Moreover, since the inorganic material film which does not have a pinhole on the resin film since the internal stress of the film obtained is small can be formed uniformly, adhesion reinforcement with the resin film of the inorganic material film is enlarged in macro.

[0020] It is inactive gas ion, for example, Ar+, to use a new trad riser, in case the inorganic material film is formed with the vacuum deposition by ion beam assistance. The positive charge accumulated in the processed substrate front face by the exposure of ion for the charge-up phenomenon is useful to neutralizing the charge on the front face of a substrate in order to cancel causing the inactive gas ion irradiated continuously to a substrate front face, and repulsion.
[0021] Inert gas, such as an argon, is used for the ion plating by high-frequency excitation as carrier gas in the vacuum of 10-4 - 10-5Torr. SiO2 which carried out heating evaporation It is what carries the membrane formation matter on a substrate with this carrier gas. etc. -- between the substrates which ionized carrier gas by high-frequency excitation before reaching a processed substrate, and it made a touch-down condition or negative carry out bias electrification -- an electric potential gradient -- attaching -- a substrate -- receiving -- SiO2 etc. -- it is the approach of accelerating and vapor-depositing the membrane formation matter with carrier gas.
[0022] Since carrier gas ion, such as an argon, is straightly accelerated with sufficient directivity to a substrate according to this approach, only the part in Mr. about several angstroms Fukashi only oxidizes from a front face, and only a surface part with the very thin resin film used as a substrate does not produce the oxidation to which even the interior of the film is arrived at so that according to plasma CVD. Moreover, as one of the descriptions of membrane formation by high frequency ion plating, even if irregularity and a big level difference are shown in a substrate front face, by the beam accelerated with sufficient directivity, it is raised that it can vapor-deposit uniformly on the whole substrate front face and that the so-called surroundings lump property is high, this property has also agreed for this purpose and formation of the inorganic material film with adhesion reinforcement high in macro with the resin film is enabled.
[0023] performing ion beam assistance, in case the inorganic material film is formed by the ion plating by high-frequency excitation -- SiO2 etc. -- the kinetic energy of the ion raises the array nature of the molecule of the membrane formation matter, therefore very precise by irradiating an ion beam on the processed substrate on which the membrane formation matter is made to deposit, -- formation of the strong film is enabled especially to acid treatment.
[0024]
[Example] Next, an example explains this invention further. Needless to say, the example hung up over below is for illustrating this invention, and does not tend to limit this invention.
[0025] an example 1 -- this example explains composition of the sill phenylene resin for using it as an interlayer insulation film of a multilayer interconnection.
[0026] The nitric acid was added to mixed stock (1 and 4-bis(methyl diethoxy silyl) benzene 35g and methanol 20g), subsequently 7g of water was dropped, stirring was performed at 50 degrees C for 3 hours, dehydration condensation of 1 of starting material and the 4-bis(methyl diethoxy silyl) benzene was carried out, and the polymer was generated.
[0027] After cooling this reaction solution, methyl-isobutyl-ketone (MIBK) 150g was added and put, and still more sufficient rinsing was performed except for the water layer. Triethylamine 50g and phenyl dimethyl chlorosilicane 80g were added to the MIBK solution after rinsing, and it silanized, having heated at 70 degrees C and stirring for 2 hours, and the hydroxyl of a polymer end was changed into the silyloxy radical.
[0028] Subsequently, the reaction solution was cooled and still more sufficient rinsing was performed, removing a water layer. A methanol is added to the MIBK solution after rinsing, and the polymer was settled, and since this polymer was dissolved in benzene, it freeze-dried, and powdered sill phenylene resin was obtained. The weight average molecular weight of this resin was about 10,000.
[0029] It applied with the spin coat method on the silicon substrate (1 micrometer of wiring thickness, minimum line width of 1 micrometer, the minimum line spacing of 1 micrometer) which formed the semiconductor device for the methanol solution of the resin powder compounded in the example 2 example 1, and gave first pass aluminum wiring. Solvent desiccation was performed for 15 minutes at 150 degrees C after spreading, subsequently heat treatment of 1 hour was performed at 450 degrees C, and membranes were formed to 1.5-micrometer thickness. The level difference on the front face of a substrate after heat treatment is 0.2 micrometers or less, and flattening of the level difference produced with first pass aluminum wiring was carried out.
[0030] In this way, it is SiO2 as it is the following on the substrate which prepared the resin layer. The film was formed. SiO2 The vacuum evaporation system used for membrane formation is shown in drawing 1 . this drawing -- setting -- 1 -- a vacuum tub and 2 -- a dome and 3 -- a substrate and 4 -- an evaporation source and 5 -- an ion gun and 6 -- for a new trad riser and 9, as for the Gascon trawl unit and 11, a power-source control unit and 10 are [the shutter of an ion gun, and 7 / a halogen lamp and 8 / an oxygen inlet port and 12] the communication trunks to an exhaust air

system.
[0031] The substrate 3 which prepared the above-mentioned resin layer in the dome 2 in the vacuum tub 1 of this vacuum evaporation system was fixed. It exhausted to 1x10-6Torr after immobilization, and Ar ion beam was irradiated for 30 seconds from the ion gun 5 at the substrate 3, maintaining the pressure in the vacuum tub 1 subsequently to 5x10-5Torr, and it defecated by performing bombardment of substrate 3 front face. Next, after carrying out the lamp exposure with the halogen lamp 7 at the substrate 3 and setting substrate skin temperature as 300 degrees C, oxygen gas was introduced in the vacuum tub 1 by the flow rate of 10 cc/s. Moreover, the evaporation source 4 heated with an electron gun while introducing Ar gas into the Gascon trawl unit 10 by the flow rate of 3 cc/s, setting ion acceleration voltage as 500V, setting a current value as 50mA and irradiating Ar ion beam which made it generate at a substrate 3 to SiO2 It was made to vapor-deposit to up to a substrate 3 by 25A/s in rate. During vacuum evaporationo, in order to maintain at 5x10-5Torr and to avoid the charge up on the front face of a substrate by Ar ion beam exposure, the degree of vacuum in a tub used the new trad riser 8 for an ion beam exposure and coincidence, and neutralized the charge.
[0032] Obtained SiO2 Thickness is 5000A, a refractive index is 1.45, and it is bulk-like SiO2. It turned out that the precise film equivalent to a refractive index 1.45 is obtained. In addition, SiO2 which formed membranes with vacuum deposition without ion beam assistance A refractive index is about 1.35. SiO2 They are the resin film and SiO2 after film formation and by the optical microscope. When the existence of a membranous crack was investigated, it was not observed at all.
[0033] Next, generating of a crack was not looked at by the resin film formed in the lower layer resin film in this example to a countless crack arising when the heat cycle shock trial of 400 degrees C - a room temperature was performed, and the inorganic material film was produced by plasma CVD etc. Moreover, it is SiO2 when the conventional approach is used in the etching processing by fluoric acid. By the film formed in this example, exfoliation was not produced at all to exfoliation of the film or the resin film arising.
[0034] After performing heat cycle shock trial and etching processing, when the electric insulation trial was performed further, it has checked that it was enough for the insulation of the insulator layer produced in this example to use it as an interlayer insulation film of a multilayer interconnection.
[0035] It is SiO2 with the vacuum deposition by ion beam assistance at example 3 example 2. It is SiO2 by ion plating so that the processed substrate which gave the sill phenylene resin film same with having used for forming the film may be used and it may explain below. The film was formed.
[0036] The used ion plating system is shown in drawing 2 . this drawing -- setting -- 21 -- a vacuum tub and 22 -- a dome and 23 -- a substrate and 24 -- an evaporation source and 25 -- for an RF generator and 28, as for DC power supply and 30, a matching box and 29 are [a high-frequency excitation coil and 26 / a halogen lamp and 27 / an argon gas inlet and 31] the communication trunks to an exhaust air system.
[0037] The substrate 23 which gave the resin film was fixed to the dome 22 in the vacuum tub 21 of this ion plating system. It exhausted to 1x10-6Torr after immobilization, and defecated by performing bombardment on the front face of a substrate under RF (13.56MHz) output 100W and argon gas pressure 2x10-4Torr. Next, after carrying out the lamp exposure with the halogen lamp 26 at the substrate 23 and setting substrate skin temperature as 300 degrees C, oxygen gas was introduced in the vacuum tub 21 by the flow rate of 10 cc/s, maintaining a yard pressure at 2x10-4Torr. The evaporation source 24 which sets a RF output to 1kW, excites the argon of carrier gas, and is heated with an electron gun in this condition to SiO2 It vapor-deposited to the substrate. 20A /and the last thickness made the evaporation rate 5000A s.
[0038] Obtained SiO2 A refractive index is 1.42 and is bulk-like SiO2. It turned out that the film almost equivalent to a refractive index 1.45 is obtained, and the precise film equivalent to bulk is obtained also in a thin film. Moreover, SiO2 They are the resin film and SiO2 after film formation and by the optical microscope. When the existence of a membranous crack was investigated, it was not observed at all.
[0039] Next, after performing through hole formation according to a conventional method, when resist exfoliation was performed using the barrel type etching system, the crack by oxidation, a membranous retreat, etc. were not observed at all. Then, two-layer eye wiring was given, the PSG film was formed with the CVD method as covering film, and the semiconductor device was made as an experiment.
[0040] After performing the heat cycle shock trial of 400 degrees C - a room temperature using this semiconductor device, when the 200-degree C elevated-temperature shelf test was performed, as for the defect, 1000 hours after was

not seen at all.
[0041] In addition, in the equipment shown in drawing 2 used in this example, by electrifying a substrate side in negative, the acceleration effectiveness of ion can be raised and the film with a more strong degree of adhesion can be obtained.
[0042] It is SiO2 on the processed substrate equipped with the sill phenylene resin film by the ion plating which uses the equipment shown in example 4 drawing 3 , and performs ion beam assistance. The film is formed. In drawing 3 , the same reference figure is given to the member of the equipment shown in drawing 2 , and the corresponding thing. Moreover, among this drawing, 41 are the Gascon trawl unit by which an ion gun and 42 were connected to the shutter of an ion gun, and 43 was connected to the ion gun, and 44 is an evaporation source 24 and a power-source control unit for ion gun 41.
[0043] The actuation in this case is SiO2 by irradiating an ion beam on a substrate, making tub internal pressure into 8x10-5Torr extent, and oscillating high frequency ion plating in the case of vacuum evaporationo, although it is fundamentally the same as the above-mentioned example 3 and. Membranes are formed. an ion beam exposure -- the kinetic energy of ion -- SiO2 the time of being deposition -- SiO2 the array nature of a molecule is raised and very precise -- the strong film is made especially to acid treatment. In addition, also in the equipment shown in drawing 3 , by electrifying a substrate side in negative, the acceleration effectiveness of ion can be raised and the film with a more strong degree of adhesion can be obtained.
[0044]
[Effect of the Invention] The low dielectric constant inorganic dielectric film of a thermal shock and the high quality which has the adhesion reinforcement which can be borne enough in back process processing of heat treatment etc. can be formed without according to this invention, flattening of the level difference produced at the multilayer-interconnection process of a semiconductor device becoming possible, and making the resin film produce a crack etc. on the substrate resin film for flattening so that clearly from the above explanation. In this way, since the interlayer insulation film which consists of formed substrate resin film for flattening and inorganic material film on it can hold an insulating property equivalent to the conventional interlayer insulation film formed using the inorganic material film, the manufacture of semiconductor devices, such as a reliable semiconductor integrated circuit, of it is attained.
[0045] Moreover, the film made from the usual resin which has an organic radical In order to prevent that the side face exposed to the through hole section at the resist exfoliation process after through hole formation oxidizes for exfoliation liquid, By using the sill phenylene resin which was excellent in oxidation resistance according to this invention to having controlled the damage of the resin film using the expensive ECR etching system It becomes possible to use the etching system of the barrel type currently used at the usual resist exfoliation process.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is a mimetic diagram explaining the vacuum evaporation system by ion beam assistance.
[Drawing 2] It is a mimetic diagram explaining the ion plating system by high-frequency excitation.
[Drawing 3] It is a mimetic diagram explaining the high-frequency excitation ion plating system by ion beam assistance.
[Description of Notations]
1 21 -- Vacuum tub
3 23 -- Substrate
4 24 -- Evaporation source
5 41 -- Ion gun
8 -- New trad riser
25 -- High-frequency excitation coil

[Translation done.]